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PATENT SPECIFICATION 971,334

DRAWINGS ATTACHED.

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971,334

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COMPLETE SPECIFICATION.

Improvements in and relating to Tubular Heat Exchangers.

We, THE ENGLISH ELECTRIC COMPANY LIMITED, of English Electric House, Strand, London, W.C.2, (formerly of Queens House, 28 Kingsway, London, W.C.2), a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to tubular heat exchangers for effecting heat exchange between a first fluid and a second fluid.

According to the invention, in such a heat exchanger including a closed vessel having fluid inlet and outlet means and being arranged for flow of said first fluid along a first general flow path longitudinally of said vessel from the fluid inlet means to the fluid outlet means, and a plurality of tubes of substantially rectangular cross-section arranged in the vessel and connected between further fluid inlet and outlet means for said second fluid, two parallel exterior faces of each said tube are arranged in planes parallel to the general direction of said first flow path, the length of each tube in the direction of flow of the second fluid through the tube being inclined with respect to the general direction of said first flow path and each tube being arranged with a space around all four faces thereof so that the first fluid may flow from the side of the tube upstream with respect to said first flow path, across and in contact with the said two exterior faces to the side of the tube downstream with respect to said first direction.

Preferably at least some of the tubes are parallel to each other.

In order that the invention may be clearly understood and readily carried into effect, two embodiments thereof will now be described with reference to the drawings accompanying the Provisional Specification, of which:—

Fig. 1 is a diagrammatic sectional elevation of a multi-pass fluid heat exchanger according to the invention;

Fig. 2 is a diagrammatic sectional plan view taken on the lines II—II of Fig. 1;

Fig. 3 is an isometric underneath view of part of the interior of the heat exchanger shown in Figs. 1 and 2, showing vortices formed in the flow of a fluid through a heat exchanger; and

Fig. 4 is a sectional elevation of a steam condenser according to the invention.

Referring firstly to Figs. 1 and 2, the heat exchanger includes a closed vessel 1 having two double-walled sides 2 and 3 and a central baffle or partition 4. The medium to be cooled (such as oil) enters the vessel 1 at the bottom through an oil inlet port 5 and leaves it at the top through an oil outlet port 6. The oil follows a generally longitudinal path up the vessel, the baffle 4 being parallel with this path, which is indicated by arrows in Fig. 1. The coolant (such as water) enters the lowest compartment 3^1 of the right-hand side double wall 3 (as seen in Figs. 1 and 2) through a water inlet port 13, rises obliquely through a nest 7^1 of tubes 7 into a second compartment 2^{11} on the left-hand side double wall 2 (as seen in Figs. 1 and 2), descends from there obliquely through another nest of tubes 7^{11} into a second compartment 3^{11} on the right-hand side, and so on. Eventually the cooled water reaches an uppermost left-hand side compartment 2^{111} through a final nest of tubes 7^{111}, and leaves the heat exchanger from these through a water outlet port 12.

The tubes 7^1, 7^{11}, 7^{111} are substantially rectangular in cross-section, the two side

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faces of each tube being in planes parallel to the oil flow path. The length of each tube (measured in the direction of water flow) is inclined to the oil flow path, and therefore also to the walls 2, 3 of the vessel, so that one end of each tube is higher than the other. There is a space around all four sides of each tube, so that oil can flow upwardly past the tubes, from the lower (upstream) side of each tube, across and in contact with the side faces of the tube, to the upper (downstream) side of the tube.

As the oil flows up the vessel 1, inter-tube "U" type vortices, diagrammatically illustrated in Fig. 3 are induced in the oil by the tubes 7. In Fig. 3, for the sake of simplicity and clarity, only one of the two compartments between the vertical baffle 4 and a side wall, and one row of tubes 7 only, are shown.

The flow of the oil or other medium to be cooled, the general direction of which is indicated in Fig. 3 by a straight arrow 10, is deflected by the tubes 7 into a crossover flow on a generally-helical path 11 and into local inter-tube U-type vortices 17. One turn of the helical path 11 may extend in fact over more tubes 7 than shown in Fig. 3, say over eight to ten tubes. Moreover tip vortices 18 develop at the junctions of the tubes 7 with the baffle 4 and with the inner faces of the wall 3 (the compartments 2^1, 3^1, 2^{11}, 3^{11} being omitted from Fig. 3). The vigorous but controlled turbulence thus induced results in a greatly improved rate of heat transfer.

Referring now to Fig. 4, the directions of flow of the fluids are substantially reversed in the steam condenser illustrated there as compared with the fluid heat exchanger shown in Figs. 1 and 2: low-pressure steam enters the condenser vessel 101 on top through a connecting hood 105, and the condensate leaves at the bottom through an outlet port 106. The side walls 102 and 103 of the condenser vessel 101 are vertically staggered with respect to one another, and there are three perforated vertical baffles 104^1, 104^{11}, and 104^{111}, parallel to these side walls, in addition to baffles 108 parallel to the plane of the drawing in Fig. 4. Two nests of cooling-water tubes, 107^1, 107^{11}, of substantially rectangular cross-section, extend obliquely between the two side walls 102 and 103 and across the baffles 104^1, 104^{11}, 104^{111}. The tubes 107 are arranged (in the same way as the tubes 7 in Fig. 1) with their side walls in planes parallel to the general direction of flow of steam.

Cooling water enters from a pipe 113 into an inlet waterbox 103^1, descends from there obliquely through the upper nest of tubes 107^1 into the upper chest portion 102^1 of an intermediate waterbox, and from there past a horizontal baffle 109 into the lower chest portion 102^{11} of the waterbox, at the bottom of the side wall 102. From there the water rises obliquely through the lower nest of tubes 107^{11} into an outlet waterbox 103^{11}, which it leaves through an outlet pipe 112.

The flow pattern in each of the vertical compartments of the vessel 101, bounded by its vertical baffles 104^1, 104^{11}, 104^{111} and 108 and/or its walls, corresponds generally to the flow pattern described with reference to Fig. 3, with of course some directions reversed.

WHAT WE CLAIM IS:—

1. A tubular heat exchanger for effecting heat exchange between a first fluid and a second fluid, including a closed vessel having fluid inlet and outlet means and being arranged for flow of said first fluid along a first general flow path longitudinally of said vessel from the fluid inlet means to the fluid outlet means, and a plurality of tubes of substantially rectangular cross-section arranged in the vessel and connected between further fluid inlet and outlet means for said second fluid, wherein two parallel exterior faces of each said tube are arranged in planes parallel to the general direction of said first general flow path, the length of each tube in the direction of flow of the second fluid through the tube being inclined with respect to the general direction of said first general flow path and each tube being arranged with a space around all four faces thereof so that the first fluid may flow from the side of the tube upstream with respect to said first flow path, across and in contact with the said two exterior faces to the side of the tube downstream with respect to said first direction.

2. A tubular heat exchanger according to Claim 1, wherein at least some of the tubes are parallel to each other.

3. A tubular heat exchanger according to Claim 1 or Claim 2, including at least one baffle arranged in the vessel parallel to the general direction of said first general flow path whereby to divide the vessel into compartments for the flow of said first fluid, the baffle or baffles being intersected by the said tubes.

4. A tubular heat exchanger according to any of Claims 1 to 3, comprising a steam condenser of which the closed vessel is arranged for entry of steam through said fluid inlet means and for exit of condensate through said fluid outlet means, and the said tubes are arranged to convey cooling water constituting said second fluid, whereby to condense the steam in the vessel.

5. A tubular heat exchanger for effecting heat exchange between a first fluid and a second fluid, substantially as herein described with reference to Figs. 1 and 2 of

the drawings accompanying the Provisional Specification.

6. A steam condenser substantially as herein described with reference to Fig. 4 of the drawings accompanying the Provisional Specification.

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Chartered Patent Agent.

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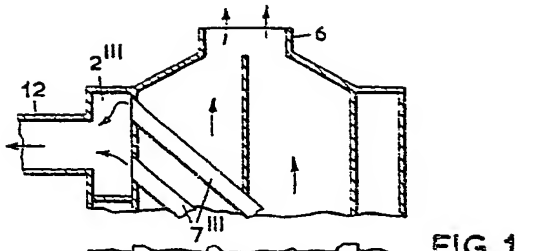
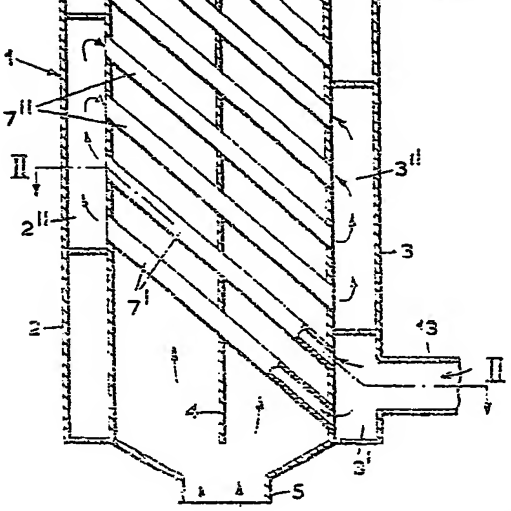


FIG. 1



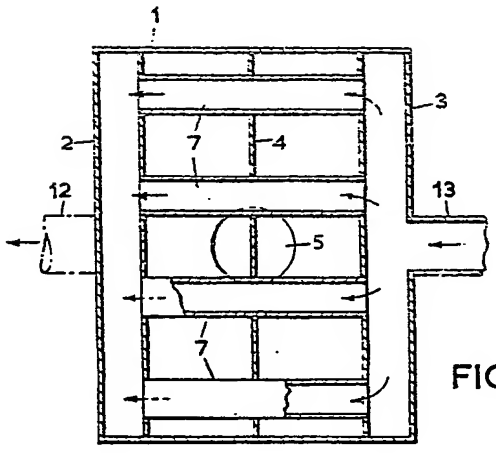


FIG. 2

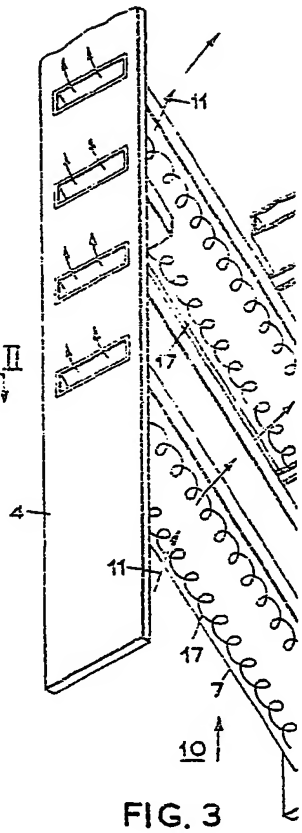


FIG. 3

971334 PROVISIONAL SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 1 & 2

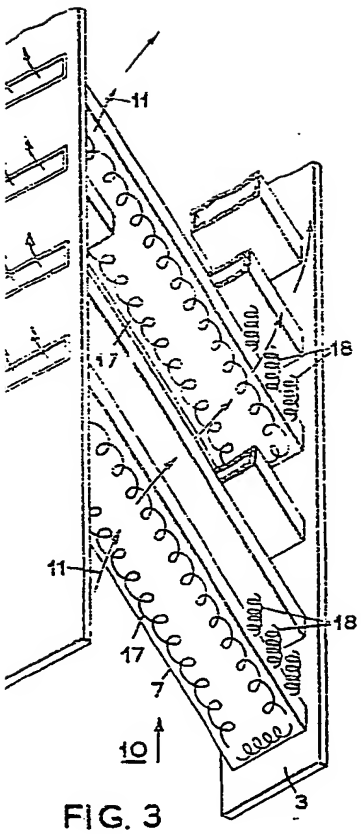


FIG. 3

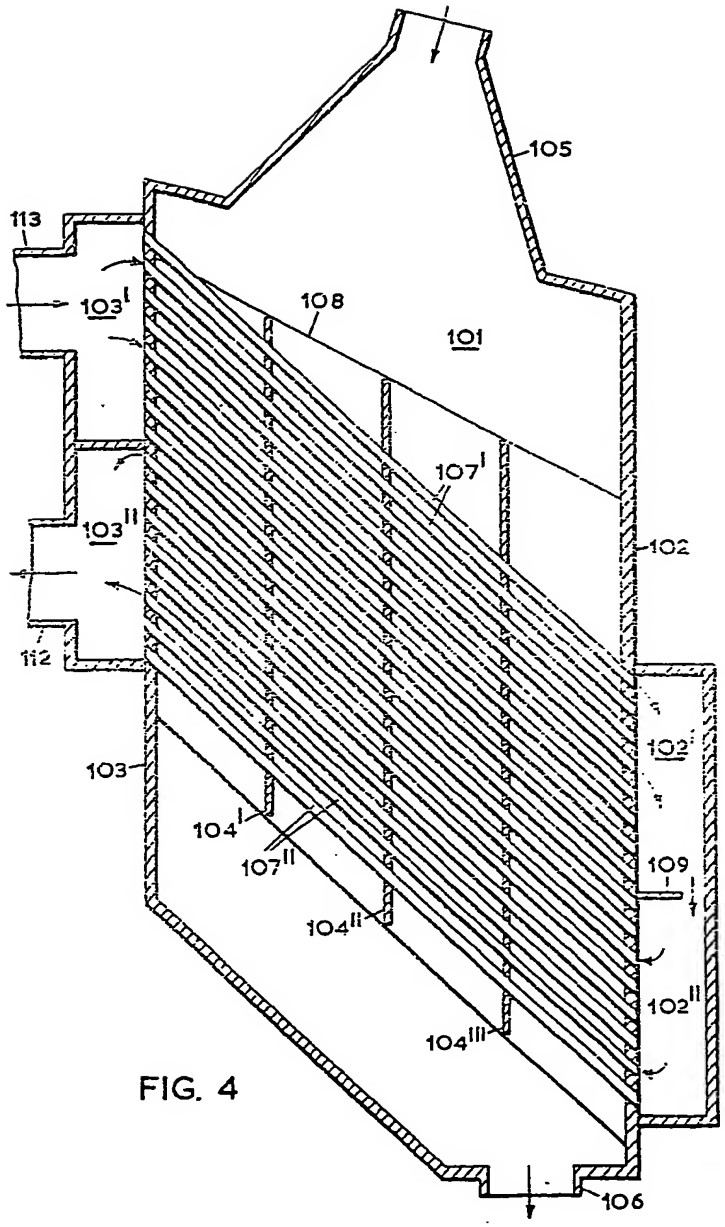


FIG. 4

971334 PROVISIONAL SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

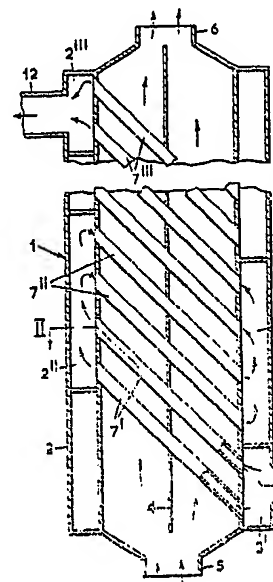


FIG. 1

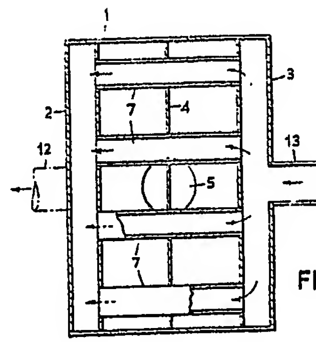


FIG. 2

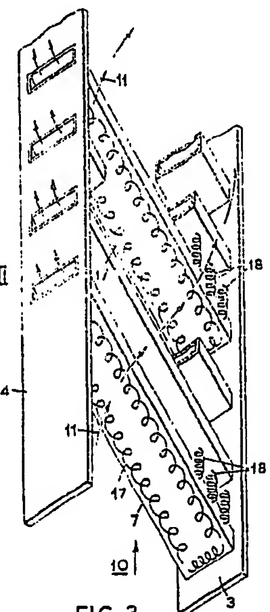


FIG. 3

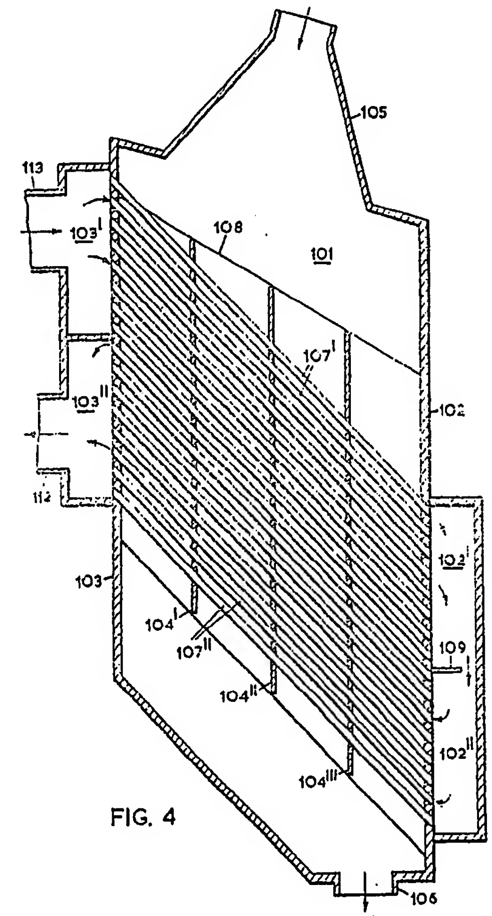


FIG. 4